# An Evaluation of a Handwashing Promotional Program in Elementary Schools

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Food and Community Safety Program
& Office of Community Assessment

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TACOMA-PIERCE COUNTY
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## Introduction

Infectious diseases continue to represent a massive burden of morbidity and mortality in the United States. These diseases place significant and growing demands upon medical resources due in part to the spread of antibiotic resistant pathogens and increased rates of nosocomial infection. Frequent and thorough handwashing is considered an effective measure to reduce the spread of infectious diseases. Effective handwashing education especially among children represents a significant and worthwhile challenge as not only are children especially susceptible to such diseases, but good handwashing habits started in childhood can bring a lifetime of benefits.

Although it is generally accepted that children should wash their hands frequently and thoroughly, the means of achieving this end is open to debate. Any publicly funded program addressing a public health issue must justify the opportunity costs associated with choosing this issue from the multitude of pressing public health problems. In addition, school based promotional programs must establish not only that they are effective, but that the benefits of the program outweigh the costs of time taken from the increasingly busy school day filled with required curriculum activities.

Even if handwashing promotion can be justified to be included within the curriculum, the choice of type of program must also be justified. Options for handwashing program include behavioral theory based programs that assume that improved handwashing will follow awareness of the issue and an understanding that individual good handwashing habits can and do make a difference.  Program options might also focus upon changing policies within a school to require handwashing at particular times of the day.  Finally, programs might emphasize practice, whereby a particular technique or product such as alcohol hand sanitizers are promoted to reduce transmission of pathogens.  This evaluation must be seen in the context of these considerations

## Literature Review

Diarrheal illness causes a significant burden of disease among children [1]. Illness rates are reflected in increased absenteeism in addition to considerable costs for treatment and lost productivity associated with parents caring for sick children. Thorough handwashing and good knowledge of handwashing issues among children have been shown to reduce fecal contamination on hands[1]. The positive effects of handwashing are often seen as self-evident, not requiring further analyses. Though considerable research has been done into the benefits of handwashing in clinical settings, its value in childcare and school settings is less clear. In addition, if resources are to be used optimally the most appropriate handwashing education techniques must be identified.

The value of handwashing in reducing the risk of infectious disease transmission has been established for more than 100 years.[2] However, the value of handwashing was arguably established considerably earlier.[3] In 1847, the Hungarian physicians Ignaz Semmelweis effectively employed handwashing to reduce mortality due to puerperal fever in a maternity ward[4]. Thanks in large part to this pioneering work; the value of handwashing and hygiene is generally accepted such that few studies have been conducted to establish its true efficacy in stopping the spread of infection. In 1988, Elaine Larson published a review of the published literature on handwashing between 1879 and 1986[5]. This review was updated in 1995[6] and provides a useful overview to the literature. These studies indicate that between these years 514 articles were published on the subject with 18% published during the last ten years. During the entire time analyzed only twenty-two of these articles related handwashing directly to the risk of infection, with the majority of articles being evaluations of products or generally brief and superficial reviews. The vast majority of studies relating risk to handwashing procedures were undertaken in clinical settings with only one study identified in a childcare setting.

Good handwashing practices are important, as hands have been demonstrated to support the survival and allow for the transmission of pathogens. Klebsiellae have been shown to survive for up to two hours after inoculation on hands.[7] Rotavirus, one of the leading causes of infant diarrhea has been shown to survive for more than four hours on hands.[8] Hepatitis A has been shown to survive well on human hands and be transferable to surfaces from contaminated hands.[9] Giardia lamblia has also been demonstrated to survive on hands and contaminate foods.[10] These last three pathogens have been noted to be especially significant as pathogens in childcare and school settings.[11]

Handwashing has been shown to reduce the number of pathogens, the amount of reduction usually expressed as a log reduction varies with both the organism and the quality of the handwashing and any chemical agent chosen. Handwashing with soap and water has been shown to result in a 1-2 log reduction in rotavirus[12], a 1 log reduction in bacteria[13] and a 1 log reduction in Giardia.[14] The perhaps surprisingly small reduction in pathogens on hands as a result of handwashing underlines the importance of repeated handwashing and improved technique in combination with typical survival rates to reduce the risk of transmission.

The importance of handwashing in clinical settings is well established. According to the CDC: “handwashing is the single most important procedure for preventing nosocomial infections”.[15] Inadequate or improper handwashing technique has been associated with nosocomial infections. This has been observed in case studies[16] and in a general assessment of the 15% to 20% of the total burden of nosocomial infections (causing approximately 4,500 deaths and costing half a billion dollars annually) that could be prevented through proper handwashing.[17] This burden of disease and associated cost explains in part that the preponderance of the literature relating to handwashing concerns in clinical settings.

Some of the strongest evidence for the effectiveness of handwashing in reducing the transmission of infectious disease occurs in case studies where the degree of protection afforded by handwashing is assessed by comparing handwashing practices of cases and controls. These types of study include an outbreak of salmonellosis among children associated with attendance at a Komodo dragon exhibit at a zoo. Children attending the exhibit who washed there hands at the zoo were more than 5 times less likely to develop salmonellosis than those who attended the exhibit and did not wash their hands.[18] Other case control studies show handwashing to be effective in reducing the incidence of E.coli 0157:H7[19] and salmonellosis associated with handling chicks and ducklings.[20]

The burden of infections in childcare centers and schools is considerable. Infections are the most common cause of absenteeism in elementary schools.[21]Absenteeism results in considerable costs due to lost productivity from caring for a sick child in addition to disruption of the learning process. Close contact and large populations makes the spread of infection harder to control. For example, the incidence of diarrhea in young children in daycare centers is two to three times higher than in the same age group cared for at home.[22] High incidence of diarrheal illness in daycares can affect schools. For example in one study, children entering the first grade who had previously attended daycare had at least six times the prevalence of giardiasis of children who had not attended day care.[23]

Incidence of diarrheal disease in childcare and school settings has been linked to fecal contamination of surfaces and to relative knowledge of hygiene. Studies have shown increased incidence of diarrhea expressed in bi-weekly parental telephone interviews were associated with greater prevalence of fecally contaminated hands and moist surfaces such as sinks.[24] Kaltenhaler[1] assessed levels of hygiene knowledge of pupils and successfully correlated poor knowledge with increased probability of fecal contamination on hands. This study also identified schools with larger proportions of their pupils with fecally contaminated hands as being more likely to have reported an outbreak of gastroenteritis in the past.

Observational studies have identified poor rates of handwashing in schools.[25] Studies directly linking handwashing with the risk of infection have, as Elaine Larson points out,[4] been relatively few. The reasons for this include the assumed value of handwashing, the logistical challenge of assessing both incidence of diarrhea and exposure to improved handwashing procedures and the ethical problem of denying a control group improved handwashing procedures. Studies of handwashing programs that have been performed have yielded mixed results. A frequently cited study relating handwashing to diarrheal incidence in childcare settings by Black[26] in 1981 identified an approximately 50% decrease in infant diarrheal rates reported by staff in daycare centers that implemented a handwashing program compared to those that did not. These findings were not repeated by Bartlett[27] whose assessment did not identify improvements in illness rates as a result of handwash promotion methods. Master[28] demonstrated 57% fewer absentees due to gastrointestinal symptoms among children at an elementary school that required handwashing four times a day compared to controls during a thirty-seven day study period. Hammond[29] identified a 20% reduction in elementary school absenteeism as a result of a program of hand sanitizer use. While Day[30] found no lasting improvement in handwashing frequency in elementary schools as a result of education alone, Early[31] demonstrated that education combined with accessible and easy to use handwashing equipment could create long lasting improvements in handwashing frequency.

As indicated in this review, this study sought to use established methods and measures that have been used in previous studies. The exception to this is the novel use of soap consumption rates as a surrogate for observed handwashing frequency measures. Although this method may be prone to error through leakage or tampering, the establishment of baseline consumption rate, and the use of these data as supportive rather than conclusive evidence justify their use. This study aimed to provide further data for the ongoing assessment of the effectiveness of handwashing education in elementary schools. Finally, this study sought to provide not only a comparison with existing literature of the effectiveness of differing educational programs, but also a necessary assessment of the effectiveness of an existing program.

## Methods

An evaluation of a handwashing promotion program at an elementary school was undertaken. The evaluation involving both pretest and posttest measures and comparison to a matched control facility. The program was provided by Tacoma-Pierce County Health Department Food and Community Safety Program (TPCHD) in elementary schools within Tacoma School District (TSD). The evaluation sought to test two hypotheses:

1. Students in a school that has participated in the handwashing education program will experience a reduction in absenteeism due to infectious illness (measured as days absent compared to days at risk and confirmed with parental interviews measured for thirty school days after the completion of the program) compared to both a thirty day period prior to the program and a matched control school.

2. Students in the participant school will wash their hands more frequently (measured by rates of soap consumption adjusted for population size measured during the thirty following the completion of the program) than both before the program and compared to students at a matched control school.

Tacoma School District (TSD) was selected as the site for the evaluation as it is the largest school district within Pierce County and so provided the widest possible selection of schools within a single district. In addition, TPCHD and TSD have established an effective working relationship in addressing public health issues and TSD staff have a long standing commitment to promoting handwashing in their schools.

Institutional Review applications were submitted to both TSD and the University of Washington (UW) and approval of the study design was granted by both institutions. The sample size was based upon Master (1997) who calculated a rate of absenteeism due to illnesses whose transmission could be influenced by handwashing in an assessment of a handwashing program. They calculated a rate of 0.02252 days of illness for every possible day of attendance for the intervention facility and 0.02999 for the control. This provides a relative risk of 0.75 and a difference in rates of 0.00747. The sample size necessary to assess a difference of this size with 80% power at the 95% confidence level assuming a standard deviation of 0.01494 (twice the expected difference) with a 2-sample design was calculated using a calculator provided by Statpages and found to be 63 in both the intervention and control facilities.

The study sample involved all pupils enrolled in grades k through 3 at two elementary school in Tacoma School District. These grades were selected as they have been the target audience of existing TPCHD curriculum materials and handwashing education and promotion programs have a more powerful effect on younger children. Schools were selected to have similar proportions of children receiving free and reduced rate lunches identified from records provided by TSD, to provide study populations of similar socio-economic status. 64.7% of the students at the school receiving the intervention received free or reduced rate lunches compared to 62.2% of the control school population. The schools were also selected as they were of similar size meaning that all students in grades k-3 could be included yet still give similar sample sizes. In addition, the schools were among the smallest within the district to minimize the size of the study population and yet provide the minimum required sample size. The schools were randomly assigned to receive the intervention or to act as control by tossing a coin. The principals of the two schools then accepted invitations to join the study with the control school receiving the intervention after the completion of the evaluation measurements.

The study population included boys and girls of all races enrolled in grades k through three at the two schools. Parental consent was not required for participation in the study as it was considered an evaluation of an existing program already being undertaken in TSD schools and absentee data was collected from existing sources in aggregate format without unique identifiers.

**Data Collection**

Absentee data was collected by school attendance personnel and recorded on data sheets provided by the investigators. When a student is absent, attendance personnel contact parents or guardians by telephone to establish the cause of the absence. The type of absence was determined by the attendance personnel to be either due to respiratory illness, gastrointestinal illness, other reasons or unknown reasons. Respiratory illnesses included colds, coughs, headaches, influenza and pinkeye. Gastrointestinal illnesses included diarrhea, nausea, vomiting and stomach ache. Other reasons included anything clearly unrelated to handwashing such as sprains, fractures, asthma, lice, vacations and routine doctor's visits. Unknown reasons included absences for which the attendance personnel was unable to contact the parent or guardian. After receiving identical training from the investigator, one staff member in each of the schools identified and recorded the absentees in that school. Attendance personnel were instructed to contact the investigator if they were unsure how to code an absence. Absentee record sheets totaling the incidence of each type of absence along with the daily enrolled populations were collected weekly by the investigator.

Soap consumption data was measured by from soap dispensers at handwash sinks used by the study population. Both schools used the same quaternary ammonium chloride based antimicrobial liquid soap supplied to all schools in the district[a]. The investigator filled all soap dispensers at the start of the study period and then refilled them to a marked refill level at regular intervals. The amount of soap used was determined by weighing the dispensing container before and after the refilling. Daily soap usage was calculated by dividing the amount of soap used by the number of school days between fillings. Early release days were counted as half school days. Soap consumption was grouped into usage at classroom handwash sinks, at boys' restroom handwash sinks and

[a] Zep FS Antimicrobial Hand Cleaner. Zep Manufacturing Company P.O. Box 2015 Atalanta, GA 30301

at girls' restroom handwash sinks. In addition, total consumption at the school was calculated. In both schools students in the study population used both handwash sinks in one pair of restrooms used fairly exclusively by the study population and another that was shared by the whole school. Soap usage was measured at both pairs of restrooms as it was felt that to exclude the commonly used restrooms would be to possibly exclude some of the effect of the program. In addition, the soap usage by students not in the study population was assumed to be constant over the entire study period and so have little effect upon changes in soap usage as a result of the program.

**Program Details**

Handwashing promotional activities were scheduled in cooperation with the school principal and were provided during a week midway through fall semester. Prior to the week's activities a presentation was offered by TPCHD to all staff in grades K-3 to familiarize them with the program, answer questions and provide background about the effectiveness of handwashing in reducing absentees.

Learning objectives included gaining an understanding of germ transmission and the importance of handwashing in preventing the spread of illnesses. Presented materials also focused upon identifying critical times when hands should be washed such as after using the restroom and before eating. Correct handwashing technique emphasizing thorough lathering and rubbing of hands for twenty seconds was also emphasized.

During the week banners bearing handwashing promotional slogans such as "Just Wash'Em" and "Dirty hands Spread Disease- Wash Them" were posted at high visibility points in the school. On the first day of the week students received an assembly-style presentation on handwashing from TPCHD staff including a costumed handwashing superhero. Students were given stickers and pencils bearing handwashing promotional messages. Students also evaluated their handwashing technique using fluorescent Glitterbug® hand lotion[b] and an ultra-violet light located in a portable 10' by 10' blackout tent. Fluorescent lotion was applied to the students' hands who then examined them under the ultra-violet light. The students then washed their hands under supervision to encourage the use of proper technique. Students then reexamined their hands under the ultra-violet light to identify any areas that were missed and should receive extra attention.

On the second day of the week, TPCHD staff provided handwashing presentations in students' classrooms. These included reading a story on the theme of handwashing for the kindergarten classes or watching a computer animated video[c] illustrating how germs are spread. In addition, all classes started a plating experiment in which students touched agar plates either before or after they washed their hands and applied an alcohol based hand sanitizer. This experiment was intended to broadly illustrate the effect of handwashing in removing germs. As a result, no attempt was made to identify or quantify the results of the cultures. The plates were taped, labeled and left in the classrooms under the teacher's supervision.

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[b] Brevis Corporation 225 West 2855 South, Salt Lake City UT 84115

Students were given coloring activity books produced by TPCHD featuring the handwashing superhero to work on during classroom handwashing activities. Teachers were given letters for the students to take home discussing what they were doing and encouraging participation at home as well. Teachers were encouraged to engage in additional activities relating to handwashing such as creating murals and asking students to complete diaries listing their handwashing. Teachers received T-shirts to give to students as incentives to participate in these activities. TPCHD staff also asked teachers to supervise their students washing their hands at key times during the day such as upon arrival, before lunch and before leaving. Teacher compliance with these requested and recommended activities was not assessed.

On either the third or fourth days of the intervention week, TPCHD staff, including the costumed character again made presentations to students in their classrooms. These presentations included a review of the learning objectives and examination of the results of the plating experiment. In addition, students again used the fluorescent hand lotion to evaluate their handwashing skills. This time students viewed their hands in tabletop viewing boxes containing UV lights[d].

Data was collected and analyzed using either Excel™ or SPSS™ version 10

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[c] The Sneeze: How Germs Are Spread. AIMS Multimedia, 9710 DeSoto Ave, Chatsworth Californias

[d] Maxibox 2, Brevis Corporation 225 West 2855 South, Salt Lake City UT 84115

## Results

### Soap Usage

Actual total soap usage at the boys restroom, girls restroom and classroom handwash sinks in each school was adjusted to control for differences in daily attendance and differences in the size of the school populations. This was achieved by dividing the amount of soap used at the different sets of handwash sinks by the sum of the students in the study population attending those days to provide a daily soap usage per student in milliliters.

Table 1 shows soap usage at all sites prior to the intervention. Considerable variation in soap usage was observed at all sites but especially at the classroom handwash sinks in the control school (range 0.295ml to 1.465ml). . The mean soap usage at all sites was higher at the control school than at the school receiving the program (program school). As

## Table 1 Adjusted Pre-Intervention Soap Consumption (ml).

| Date | Classroom Pre-Intervention Control | Classroom Pre-Intervention Program | Boys Restroom Pre-Intervention Control | Boys Restroom Pre-Intervention Program | Girls Restroom Pre-Intervention Control | Girls Restroom Pre-Intervention Program | All Handwash Pre-Intervention Control | All Handwash Pre-Intervention Program |
|---|---|---|---|---|---|---|---|---|
| 9/6 | | | | | | | | |
| 9/7 | | | | | | | | |
| 9/10 | | | | | | | | |
| 9/11 | | | | | | | | |
| 9/12 | | | | | | | | |
| 9/13 | 0.994 | | 0.994 | | 0.917 | | 2.905 | |
| 9/14 | | 0.658 | | 0.826 | | 1.096 | | 2.580 |
| 9/17 | | | | | | | | |
| 9/18 | 0.913 | | 1.142 | | 0.913 | | 2.968 | |
| 9/19 | | | | | | | | |
| 9/20 | | 0.921 | | 0.716 | | 1.382 | | 3.019 |
| 9/21 | | | | | | | | |
| 9/24 | 0.833 | | 0.944 | | 1.000 | | 2.778 | |
| 9/25 | | 0.747 | | 0.611 | | 1.019 | | 2.378 |
| 9/26 | | | | | | | | |
| 9/27 | 0.295 | | 1.241 | | 1.743 | | 3.279 | |
| 9/28 | | 1.088 | | 0.735 | | 1.170 | | 2.993 |
| 10/1 | | | | | | | | |
| 10/2 | 1.467 | | 1.113 | | 2.103 | | 4.683 | |
| 10/3 | | | | | | | | |
| 10/4 | | 0.647 | | 0.477 | | 1.430 | | 2.554 |
| 10/5 | 0.771 | | 1.223 | | 2.853 | | 4.847 | |
| 10/8 | | | | | | | | |
| 10/9 | | 0.735 | | 0.495 | | 1.079 | | 2.309 |
| 10/10 | | | | | | | | |
| 10/11 | 0.660 | | 0.583 | | 1.375 | | 2.618 | |
| 10/15 | | 0.768 | | 0.445 | | 0.645 | | 1.859 |
| 10/16 | | | | | | | | |
| 10/17 | 0.909 | | 2.370 | | 0.611 | | 3.889 | |
| 10/18 | | | | | | | | |
| 10/19 | | 0.695 | | 0.530 | | 1.391 | | 2.616 |
| **Mean** | 0.855 | 0.782 | 1.201 | 0.604 | 1.439 | 1.152 | 3.496 | 2.539 |
| **StDev** | 0.329 | 0.150 | 0.517 | 0.140 | 0.753 | 0.259 | 0.874 | 0.375 |
| **Lower 95%CI** | 0.627 | 0.678 | 0.843 | 0.507 | 0.918 | 0.972 | 2.890 | 2.278 |
| **Upper 95%CI** | 1.084 | 0.887 | 1.559 | 0.702 | 1.961 | 1.331 | 4.102 | 2.799 |

result, the total mean soap usage was 3.496ml at the control school compared to 2.539 ml for the program school. However, the high degree of variance observed in soap usage and small sample size resulting in broad confidence intervals around the mean soap usage at each site means that only at the classroom handwash sinks and all handwash sinks was the soap usage significantly greater for the control school than the program school.

Table 2 shows adjusted soap usage at both schools during the intervention. In contrast with the pre-intervention measurements, the mean daily soap consumption in the program school was consistently higher in all four measurement categories than the control school, however the small sample size precludes calculation of the significance of these differences. Large increases in the amount of soap use were observed at all sites at program school compared to the pre-intervention measure. Increases ranged from a 119% increase at the girls' restroom handwash sinks to 146% at the classroom handwash sinks. This compares to differences in soap usage at the control school handwash sinks ranging from a 36% decrease at the classroom handwash sinks to an 85% increase at the girls' restroom handwash sinks.

**Table 2 Adjusted Soap Usage During Intervention (ml)**

| | Classroom Intervention | | Boys Restroom Intervention | | Girls Restroom Intervention | | All Handwash Sinks Intervention | |
|---|---|---|---|---|---|---|---|---|
| | Control | Program | Control | Program | Control | Program | Control | Program |
| 10/22 | | | | | | | | |
| 10/23 | 0.546 | | 1.093 | | 2.285 | | 3.924 | |
| 10/24 | | 1.163 | | 1.371 | | 1.634 | | 4.169 |
| 10/25 | | | | | | | | |
| 10/26 | | 2.690 | | 1.417 | | 3.039 | | 7.146 |
| **Mean** | 0.546 | 1.927 | 1.093 | 1.394 | 2.285 | 2.337 | 3.924 | 5.657 |
| **% change from pre-intervention** | -36% | 146% | -9% | 131% | 85% | 119% | 11% | 123% |

Table 3 shows adjusted soap usage at both schools after the intervention. Again, significant variation in soap usage was observed during this period with total soap usage ranging from 2.171ml to 3.991 ml in the control school and between 1.486 ml and 3.660 ml in the program school. Mean soap usage was higher at classroom and girls' restroom handwash sinks in the program school than the control, 0.817ml compared to .813ml and 1.081 compared to .795ml respectively, although the differences were not significant. Soap usage at the boys' restroom handwash sinks was significantly greater at the control school than the program school, 1.054ml compared to 0.560 respectively. Comparing mean soap consumption in the pre and post intervention periods indicates that soap usage decreased after the intervention for all but the program school classroom handwash sinks. However, the amount of decrease was less for the program school than the control school with total soap used at all sited in the program school decreasing by 3% compared to a decrease of 23% for the control school.

## Table 3 Post-Intervention Adjusted Soap Usage (ml)

| | Classroom Post-Intervention | | Boys Restroom Post-Intervention | | Girls Restroom Post-Intervention | | All Handwash Post-Intervention | |
|---|---|---|---|---|---|---|---|---|
| | Control | Program | Control | Program | Control | Program | Control | Program |
| 10/29 | 1.020 | | 0.953 | | 2.018 | | 3.991 | |
| 10/30 | | | | | | | | |
| 10/31 | | | | | | | | |
| 11/1 | | 0.938 | | 0.691 | | 2.031 | | 3.660 |
| 11/2 | | | | | | | | |
| 11/5 | 0.601 | | 0.778 | | 0.805 | | 2.184 | |
| 11/6 | | | | | | | | |
| 11/7 | | 1.008 | | 0.550 | | 1.385 | | 2.943 |
| 11/8 | | | | | | | | |
| 11/9 | | | | | | | | |
| 11/13 | 0.724 | | 1.113 | | 0.724 | | 2.562 | |
| 11/14 | | 0.441 | | 0.533 | | 0.943 | | 1.916 |
| 11/15 | | | | | | | | |
| 11/16 | | | | | | | | |
| 11/19 | 0.713 | | 1.002 | | 0.457 | | 2.171 | |
| 11/20 | | 1.041 | | 0.557 | | 1.124 | | 2.722 |
| 11/21 | | | | | | | | |
| 11/26 | | | | | | | | |
| 11/27 | | | | | | | | |
| 11/28 | | | | | | | | |
| 11/29 | 0.818 | 0.751 | 1.032 | 0.529 | 0.545 | 0.918 | 2.395 | 2.198 |
| 12/3 | | | | | | | | |
| 12/4 | | | | | | | | |
| 12/5 | | | | | | | | |
| 12/6 | 0.583 | | 1.424 | | 0.269 | | 2.276 | |
| 12/7 | | 0.576 | | 0.367 | | 0.543 | | 1.486 |
| 12/10 | | | | | | | | |
| 12/11 | | | | | | | | |
| 12/12 | | | | | | | | |
| 12/13 | | | | | | | | |
| 12/14 | 1.234 | 0.965 | 1.072 | 0.692 | 0.746 | 0.627 | 3.052 | 2.284 |
| **Mean** | 0.813 | 0.817 | 1.054 | 0.560 | 0.795 | 1.081 | 2.844 | 2.458 |
| **StDev** | 0.237 | 0.234 | 0.196 | 0.111 | 0.571 | 0.506 | 0.746 | 0.717 |
| **Lower 95%CI** | 0.649 | 0.655 | 0.918 | 0.483 | 0.399 | 0.730 | 2.327 | 1.961 |
| **Upper 95%CI** | 0.977 | 0.979 | 1.189 | 0.637 | 1.191 | 1.432 | 3.362 | 2.955 |
| **Post-Pre Difference in Mean** | -5% | 4% | -14% | -8% | -81% | -6% | -23% | -3% |

Comparison of soap usage at girls' and boys' restroom handwash sinks provides an interesting picture of gender differences in handwashing habits. A direct comparison of mean soap usage at girls and boy's restroom handwash sinks is shown in table 4. Total soap usage in milliliters for each gender has been divided by the number of students of each gender enrolled in the school at the start of the study period. This adjusts for the slight differences in the proportions of each gender at the two schools, (113 boys and 121 girls at the control school compared to 124 boys and 119 girls at the program school at the start of the school year). The total soap usage indicated in this table sums these adjusted gender totals with the classroom totals in tables 1 through 3 and provides a better impression of the overall soap usage than the relative totals provided in tables 1 to 3.

**Table 4 Adjusted Mean Total Soap Usage at Girls', Boys' and All Handwash Sinks**

| | Control | | Program | | All Handwash Sinks | |
|---|---|---|---|---|---|---|
| | Pre-Intervention | | Pre-Intervention | | Pre-Intervention | |
| | Boys | Girls | Boys | Girls | Control | Program |
| **Mean** | 2.392 | 2.677 | 1.155 | 2.294 | 5.924 | 4.231 |
| **Lower 95%CI** | 2.034 | 2.155 | 1.058 | 2.114 | 5.318 | 3.971 |
| **Upper 95%CI** | 2.750 | 3.198 | 1.252 | 2.473 | 6.530 | 4.491 |
| | Intervention | | Intervention | | Intervention | |
| **Mean** | 2.175 | 4.250 | 2.664 | 4.654 | 6.971 | 9.245 |
| | Post-Intervention | | Post-Intervention | | Post-Intervention | |
| **Mean** | 2.098 | 1.478 | 1.070 | 2.154 | 4.389 | 4.041 |
| **Lower 95%CI** | 1.962 | 1.082 | 0.993 | 1.803 | 3.674 | 3.544 |
| **Upper 95%CI** | 2.233 | 1.874 | 1.147 | 2.505 | 5.104 | 4.538 |

From table 4 we can see that at the program school, girls use consistently more soap than boys during all phases of the study. By contrast, for the control school, soap usage was similar for boys and girls during the pre-intervention period but lower for the girls during the post-intervention period.

Although the total soap used includes soap used by students not in the study population, it can suggest the overall number of handwashings occurring per student to see if this conforms with recommended minimums. Using observations of handwashings at a local fair[e] handwashers used on average 2.9 ml of liquid soap per handwashing. Assuming students washed their hands the minimum 3 times suggested by the program organizers, in addition to visits to the restroom, total soap usage per student should be in excess of 9 ml per day. Interestingly, only during the intervention at the program school was this amount of soap usage achieved. Clearly these data are approximate and contain significant possible sources of error, however they suggest that students are generally not using the quantity of soap that would be expected to comply with recommended handwashing practices.

Figure 1, 2, 3 and 4 show total daily soap consumption at all handwash, classroom handwash sinks, boys' restroom handwash sinks and girls restroom handwash sinks in the program and control school. The charts again show considerable variance in soap usage at all sites. They also all indicate a sharp increase in soap usage at the program school around the end of the intervention period. These peaks are followed by sharp drop back to levels similar to the pre-intervention period.

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[e] TPCHD unpublished program data

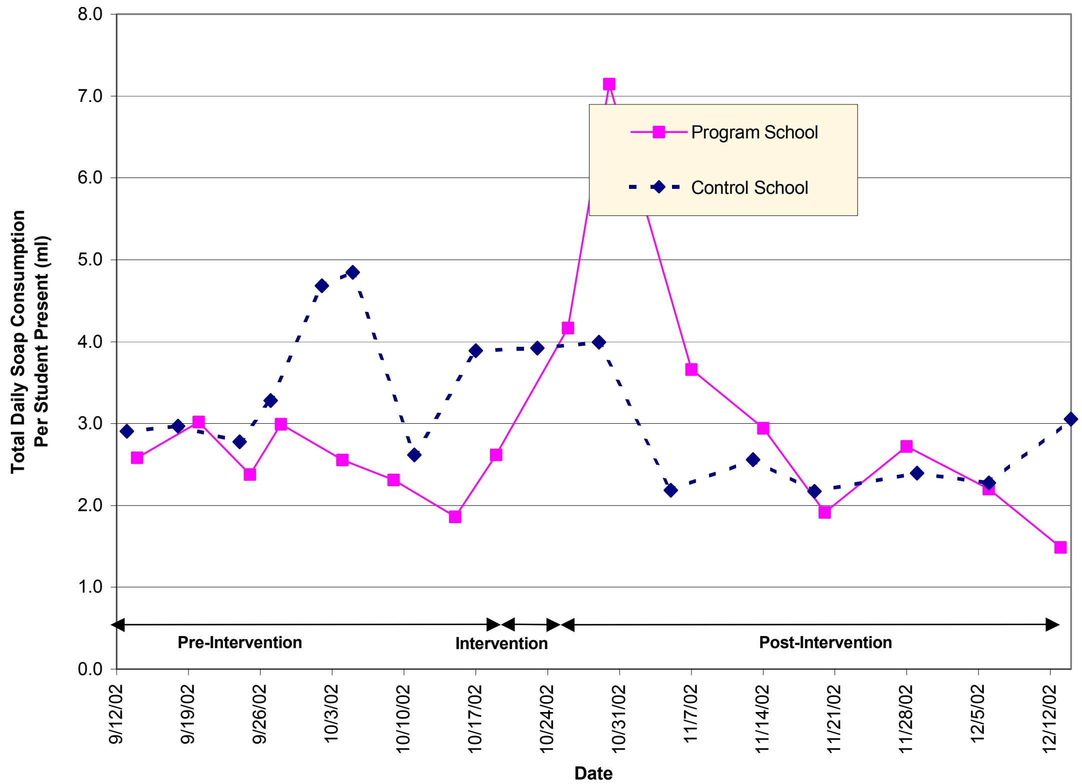


**Figure 1 Daily Total Soap Usage at Program and Control Schools**

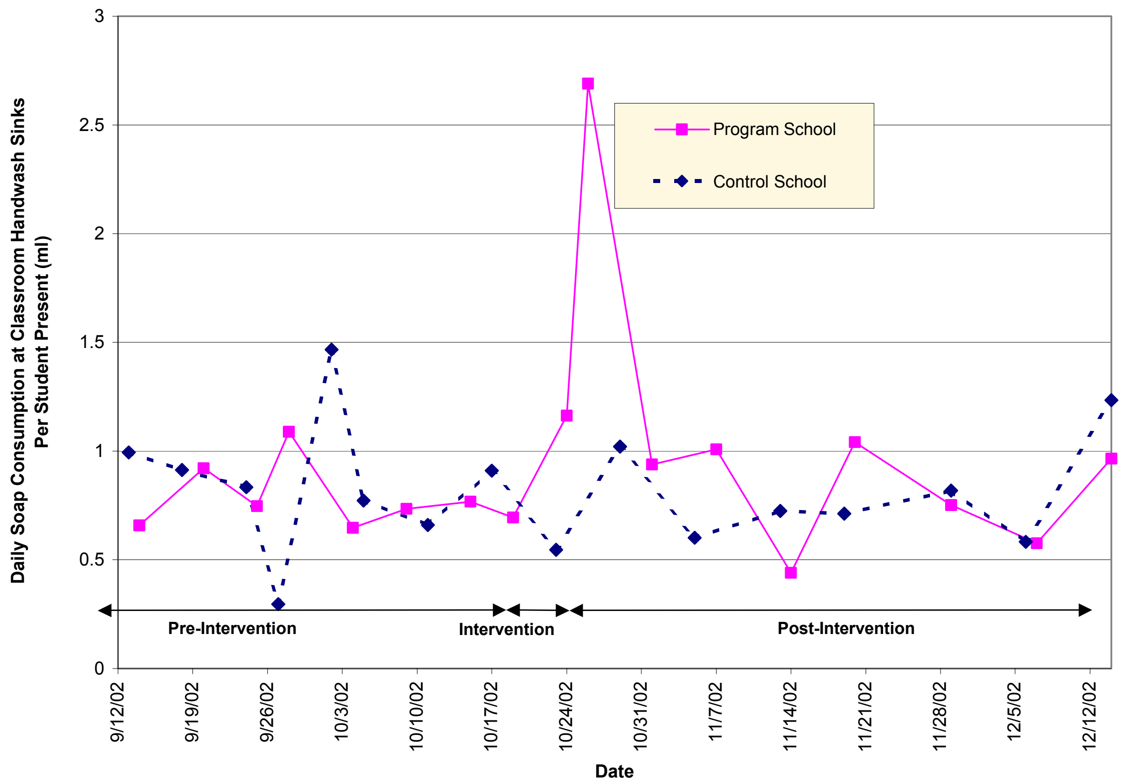


**Figure 2 Mean Daily Soap Usage at Classroom Handwash Sinks in Program and Control Schools**

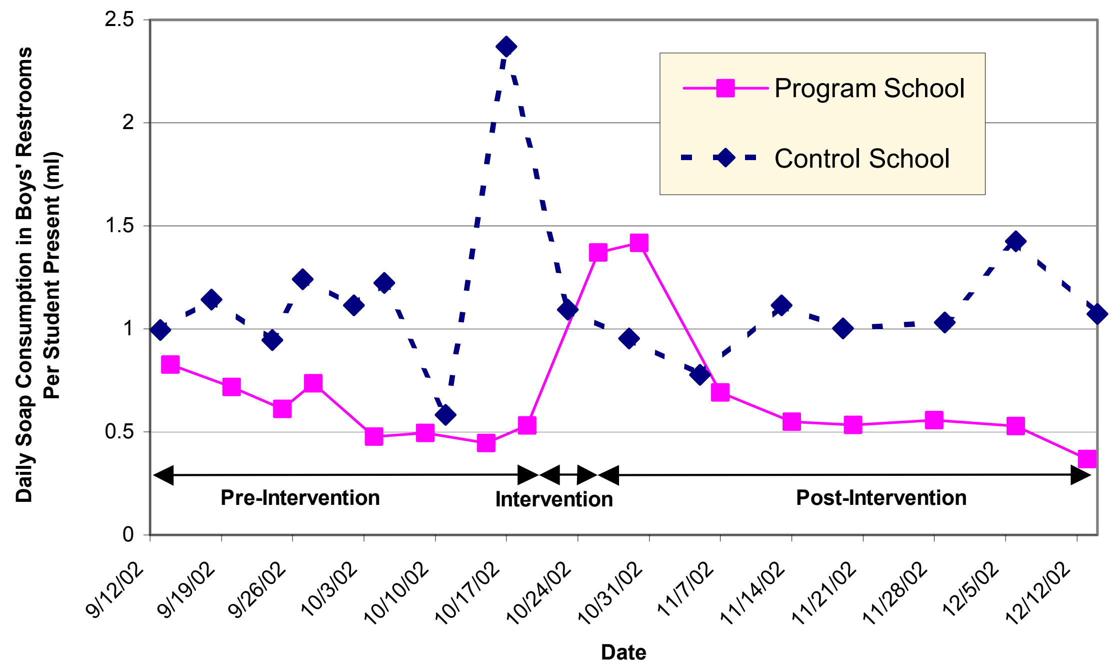


**Figure 3 Mean Daily Soap Usage at Boys' Restroom Handwash Sinks in Program and Control Schools**

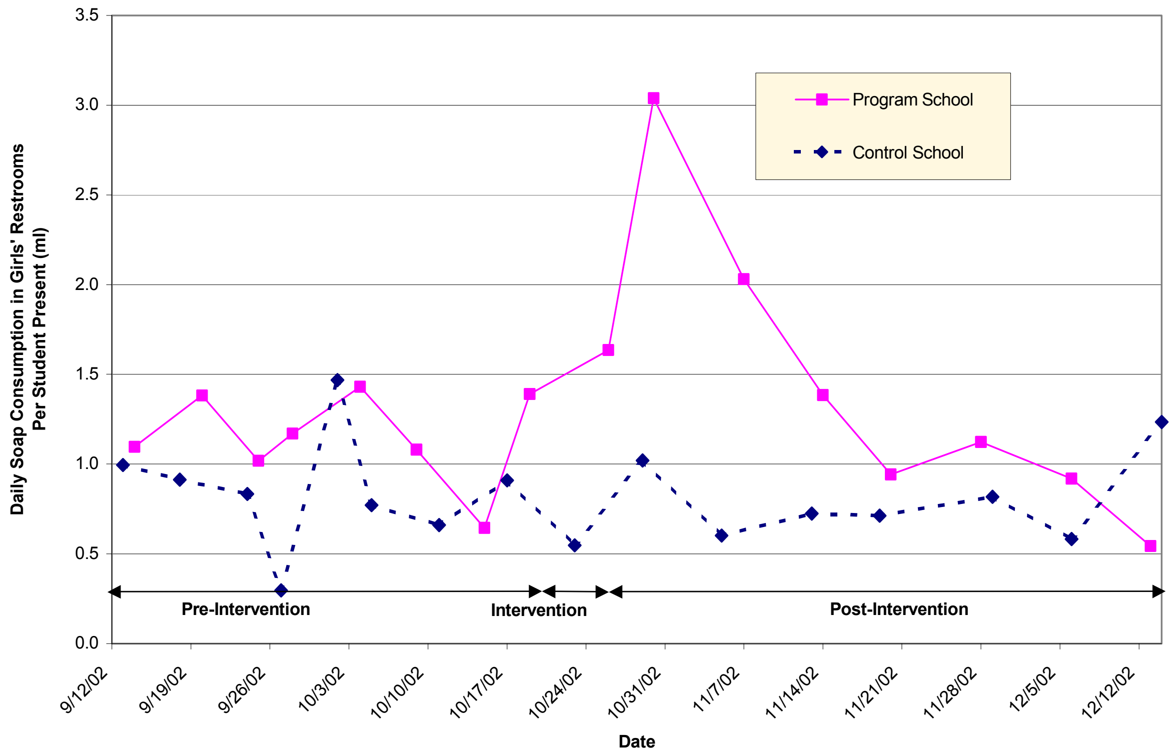


**Figure 4 Mean Daily Soap Usage at Girls' Restroom Handwash Sinks in Program and Control Schools**

The charts also suggest a slight trend of soap usage decreasing during the entire study period. To test this, Spearman's rank correlation coefficients were calculated assessing the correlation between mean soap usage and time measured by the number of days into the measurement period. The results of this analysis are shown in table 4. Correlations were generally negative except for soap usage at the program school classroom handwash sinks and the boys' restroom handwash sinks at the control school. None of the correlations however achieved significance except for soap usage at the girls' restroom at the control school which showed a significant moderate correlation (-0.587, p=0.017).

## Table 5 Correlations Between Time and Mean Soap Usage at handwash Sinks in Program and Control Schools

| | Classroom Handwash Sinks | | Boys Restroom Handwash Sinks | | Girls Restroom Handwash Sinks | | All Handwash Sinks | |
|---|---|---|---|---|---|---|---|---|
| | Control | Program | Control | Program | Control | Program | Control | Program |
| Correlation[f] Coefficient | -0.179 | 0.109 | 0.057 | -0.260 | -0.587 | -0.323 | -0.413 | -0.294 |
| Sig. (2-tailed) | 0.506 | 0.677 | 0.833 | 0.313 | 0.017 | 0.206 | 0.112 | 0.252 |

The null hypothesis that there was no difference between pre and post rates of soap usage was tested using an exact test. The results of these tests are displayed in Table 5.

## Table 6 Comparison of Differences Between Pre and Post-Intervention

| | Classroom Handwash Sinks | | Boys Restroom Handwash Sinks | | Girls Restroom Handwash Sinks | | All Handwash Sinks | |
|---|---|---|---|---|---|---|---|---|
| | Control | Program | Control | Program | Control | Program | Control | Program |
| Post-Pre Difference in Mean | -5% | 4% | -14% | -8% | -81% | -6% | -23% | -3% |
| Exact Sig[g] | 0.444 | 0.536 | 0.613 | 0.694 | 0.029 | 0.397 | 0.040 | 0.613 |

Significant differences between pre and post measures were observed at both the control school girls' restroom handwash sinks (p= 0.029) and for all handwash sinks at the control school (p= 0.040). This suggests that though soap usage declined for both schools although it declined significantly less at the girls' restroom handwash sinks in the program school compared to the control.

[f] Spearman's rank correlation coefficient was employed to control for the outliers associated with the soap usage during the intervention at the program school.

Additionally, differences in soap usage between program and control schools were compared directly using an exact test. The results of this analysis are displayed in Table 6.

### Table 7 Comparison of Differences Between Program and Control School Pre and Post-Intervention and Mean Soap Usage Rates.

| | Classroom Handwash Sinks | | Boys Restroom Handwash Sinks | | Girls Restroom Handwash Sinks | | All Handwash Sinks | |
|---|---|---|---|---|---|---|---|---|
| | **Pre** | **Post** | **Pre** | **Post** | **Pre** | **Post** | **Pre** | **Post** |
| **Difference in ml (Program- Control)** | -0.073 | 0.004 | -0.597 | -0.494 | -0.288 | 0.287 | -0.958 | -0.386 |
| **Exact Sig.** | 0.328 | 0.805 | 0.001 | 0.001 | 0.798 | 0.165 | 0.010 | 0.535 |

Although mean soap usage was lower for the program school at both classroom and girls' handwash sinks than the control school prior to the intervention, these differences were not significant. In contrast, soap usage at the boys' restroom handwash sinks was significantly lower (p= 0.001) at the program school handwash sink than the control. After the intervention mean soap usage at both the classroom and girls' restroom handwash sinks were higher for the program school although the differences were not significant. The significantly lower rate of soap usage at the program school boys' restroom handwash sinks remained after the intervention. Overall, soap usage at the program school handwash sinks was lower than the control although the difference prior to the intervention was significant (p=0.010), the difference in the period after the intervention was not (p=0.535).

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[g] Mann-Whitney U test not corrected for ties

## Absentees

Enrollment at the two schools remained fairly stable during the study period ranging from 231 to 239 for the control school and between 232 and 254 for the program school. Absences for all categories varied considerably during the study period. Daily unadjusted incidence of for respiratory illness ranged from 1 to 7 (median 3) for the control and 0 to 5 (median ) 1 for the program school. For gastrointestinal illness the range was 0 to 12 (median 1) for the control and 0 to 8 (median 1) for the program school. Absences for other reasons generally accounted for the largest proportion of the absences ranging from 0 to14 (median 3) for the control school to 0 to 11 (median 4) for the control. Absences for unknown reasons ranged from 0 to 7 (median 2) for the control and 0 to 9 (median3) for the program. Overall, total absences ranged from 0 to 22 (median 10) for the control and 0 to 20 (median 10) for the program school. Absences were calculated as rates per student at risk per day and are displayed in tables 7, 8 and 9.

## Table 8 Pre-Intervention Absentee Rates Per Student Enrolled for Program and Control Schools

| Date | Respiratory Abs. Pre-Intervent. | | Gastro. Abs. Pre-Intervent | | Other Absences. Pre-Intervent | | Unknown Abs Pre-Intervent | | Total Absences Pre-Intervent | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cont. | Prog. | Cont. | Prog. | Cont. | Prog. | Cont. | Prog. | Cont. | Prog. |
| 9/6 | 0.013 | 0.000 | 0.009 | 0.000 | 0.017 | 0.008 | 0.000 | 0.012 | 0.039 | 0.021 |
| 9/7 | 0.004 | 0.000 | 0.004 | 0.000 | 0.004 | 0.012 | 0.000 | 0.021 | 0.013 | 0.033 |
| 9/10 | 0.013 | 0.000 | 0.000 | 0.004 | 0.004 | 0.009 | 0.004 | 0.026 | 0.022 | 0.038 |
| 9/11 | 0.013 | 0.000 | 0.004 | 0.004 | 0.056 | 0.021 | 0.000 | 0.026 | 0.074 | 0.051 |
| 9/12 | 0.017 | 0.009 | 0.009 | 0.000 | 0.004 | 0.009 | 0.009 | 0.004 | 0.039 | 0.021 |
| 9/13 | 0.017 | 0.009 | 0.039 | 0.000 | 0.000 | 0.013 | 0.000 | 0.000 | 0.056 | 0.021 |
| 9/14 | 0.009 | 0.000 | 0.052 | 0.000 | 0.000 | 0.004 | 0.000 | 0.013 | 0.061 | 0.017 |
| 9/17 | 0.021 | 0.012 | 0.026 | 0.000 | 0.021 | 0.012 | 0.004 | 0.028 | 0.073 | 0.051 |
| 9/18 | 0.009 | 0.004 | 0.017 | 0.004 | 0.013 | 0.008 | 0.000 | 0.012 | 0.039 | 0.028 |
| 9/19 | 0.009 | 0.016 | 0.009 | 0.004 | 0.009 | 0.008 | 0.004 | 0.004 | 0.030 | 0.031 |
| 9/20 | 0.004 | 0.008 | 0.004 | 0.008 | 0.030 | 0.016 | 0.009 | 0.008 | 0.047 | 0.039 |
| 9/21 | 0.013 | 0.000 | 0.009 | 0.020 | 0.004 | 0.004 | 0.000 | 0.012 | 0.026 | 0.035 |
| 9/24 | 0.013 | 0.000 | 0.000 | 0.012 | 0.013 | 0.024 | 0.021 | 0.008 | 0.047 | 0.043 |
| 9/25 | 0.013 | 0.000 | 0.000 | 0.000 | 0.009 | 0.020 | 0.013 | 0.004 | 0.034 | 0.024 |
| 9/26 | 0.026 | 0.000 | 0.004 | 0.000 | 0.004 | 0.031 | 0.004 | 0.016 | 0.038 | 0.047 |
| 9/27 | 0.021 | 0.000 | 0.009 | 0.000 | 0.004 | 0.020 | 0.013 | 0.020 | 0.047 | 0.039 |
| 9/28 | 0.026 | 0.000 | 0.004 | 0.004 | 0.009 | 0.008 | 0.004 | 0.008 | 0.043 | 0.020 |
| 10/1 | 0.017 | 0.004 | 0.000 | 0.004 | 0.021 | 0.022 | 0.017 | 0.022 | 0.054 | 0.052 |
| 10/2 | 0.017 | 0.009 | 0.013 | 0.009 | 0.008 | 0.047 | 0.004 | 0.017 | 0.042 | 0.082 |
| 10/3 | 0.004 | 0.004 | 0.017 | 0.004 | 0.000 | 0.009 | 0.004 | 0.000 | 0.025 | 0.017 |
| 10/4 | 0.013 | 0.004 | 0.004 | 0.000 | 0.013 | 0.026 | 0.013 | 0.022 | 0.042 | 0.052 |
| 10/5 | 0.008 | 0.009 | 0.008 | 0.000 | 0.013 | 0.022 | 0.017 | 0.013 | 0.046 | 0.043 |
| 10/8 | 0.017 | 0.009 | 0.004 | 0.013 | 0.013 | 0.013 | 0.013 | 0.009 | 0.046 | 0.043 |
| 10/9 | 0.017 | 0.009 | 0.013 | 0.009 | 0.008 | 0.013 | 0.008 | 0.009 | 0.046 | 0.039 |
| 10/10 | 0.004 | 0.009 | 0.004 | 0.017 | 0.025 | 0.017 | 0.000 | 0.009 | 0.034 | 0.052 |
| 10/11 | 0.021 | 0.017 | 0.004 | 0.013 | 0.021 | 0.030 | 0.008 | 0.004 | 0.055 | 0.065 |
| 10/15 | 0.013 | 0.009 | 0.000 | 0.026 | 0.013 | 0.043 | 0.013 | 0.009 | 0.038 | 0.085 |
| 10/16 | 0.021 | 0.004 | 0.004 | 0.004 | 0.009 | 0.017 | 0.030 | 0.009 | 0.064 | 0.034 |
| 10/17 | 0.017 | 0.000 | 0.000 | 0.004 | 0.017 | 0.013 | 0.009 | 0.013 | 0.043 | 0.030 |
| 10/18 | 0.021 | 0.004 | 0.004 | 0.000 | 0.009 | 0.022 | 0.004 | 0.004 | 0.038 | 0.030 |
| 10/19 | 0.017 | 0.000 | 0.004 | 0.004 | 0.009 | 0.013 | 0.013 | 0.000 | 0.043 | 0.017 |
| **Mean** | **0.014** | **0.005** | **0.009** | **0.005** | **0.012** | **0.017** | **0.008** | **0.012** | **0.043** | **0.039** |
| **Lower CI** | **0.010** | **0.001** | **0.001** | **0.001** | **0.005** | **0.010** | **0.003** | **0.006** | **0.034** | **0.027** |
| **Upper CI** | **0.019** | **0.008** | **0.017** | **0.010** | **0.020** | **0.024** | **0.013** | **0.017** | **0.053** | **0.051** |

Table 7 again illustrates the variability of all types of absentees during the study period. This is especially noticeable in the respiratory and gastrointestinal absentees possibly reflecting small clusters of communicable disease typical of elementary schools where young children are in close proximity. For example, on September 14th the control school gastrointestinal absentee rate was 0.052, 13 times the median gastrointestinal absentee rate for that period. From start to finish, this period of elevated gastrointestinal absentees lasted six school days.

The variability of the data are reflected in broad 95% confidence intervals around the absentee rate means. For example, mean respiratory and gastrointestinal absences were lower in the program school than the control although this difference was not significant for gastrointestinal absences. Likewise, mean absentee rates for other and unknown reasons, although higher in the program school, were significantly so.

## Table 9 Absentee Rates Per Student Enrolled for Program and Control Schools During Intervention

| Date | Respiratory Abs. Intervention | | Gastro. Abs. Intervention | | Other Absences. Intervention | | Unknown Abs Intervention | | Total Absences Intervention | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cont. | Prog. | Cont. | Prog. | Cont. | Prog. | Cont. | Prog. | Cont. | Prog. |
| 10/22 | 0.017 | 0.012 | 0.004 | 0.004 | 0.017 | 0.032 | 0.017 | 0.008 | 0.055 | 0.055 |
| 10/23 | 0.017 | 0.012 | 0.000 | 0.004 | 0.013 | 0.028 | 0.013 | 0.008 | 0.043 | 0.051 |
| 10/24 | 0.008 | 0.004 | 0.000 | 0.000 | 0.013 | 0.016 | 0.021 | 0.020 | 0.042 | 0.040 |
| 10/25 | 0.008 | 0.000 | 0.000 | 0.004 | 0.017 | 0.012 | 0.021 | 0.016 | 0.046 | 0.032 |
| 10/26 | 0.008 | 0.004 | 0.000 | 0.012 | 0.017 | 0.016 | 0.021 | 0.012 | 0.046 | 0.043 |
| **Mean** | **0.012** | **0.006** | **0.001** | **0.005** | **0.015** | **0.021** | **0.019** | **0.013** | **0.047** | **0.044** |

The rates of absentees during the intervention shown in table 8 do not indicate clear differences between the program and control schools. Although respiratory absence rates were higher in the control school than the program school during this period, the reverse was true for absences for gastrointestinal illnesses. Likewise, although absences for other reasons were higher in the program school during the intervention, the control school had the higher rate of absences for unknown reasons. Caution should be applied to the interpretation of these differences, as confidence intervals were not calculated due to the small number of data points.

### Table 10 Post-Intervention Absentee Rates Per Student Enrolled for Program and Control Schools

| Date | Respiratory Abs. Post-Intervent. | | Gastro. Abs. Post-Intervent. | | Other Absences. Post-Intervent. | | Unknown Abs Post-Intervent. | | Total Absences Post-Intervent. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cont. | Prog. | Cont. | Prog. | Cont. | Prog. | Cont. | Prog. | Cont. | Prog. |
| 10/29 | 0.017 | 0.000 | 0.013 | 0.000 | 0.013 | 0.012 | 0.008 | 0.024 | 0.051 | 0.036 |
| 10/30 | 0.004 | 0.000 | 0.008 | 0.000 | 0.025 | 0.016 | 0.004 | 0.020 | 0.042 | 0.036 |
| 10/31 | 0.004 | 0.008 | 0.000 | 0.008 | 0.013 | 0.012 | 0.000 | 0.020 | 0.017 | 0.047 |
| 11/1 | 0.013 | 0.004 | 0.030 | 0.012 | 0.013 | 0.020 | 0.013 | 0.012 | 0.068 | 0.047 |
| 11/2 | 0.025 | 0.004 | 0.008 | 0.000 | 0.008 | 0.024 | 0.021 | 0.016 | 0.063 | 0.043 |
| 11/5 | 0.025 | 0.004 | 0.004 | 0.000 | 0.008 | 0.016 | 0.000 | 0.004 | 0.038 | 0.024 |
| 11/6 | 0.004 | 0.004 | 0.021 | 0.000 | 0.017 | 0.020 | 0.004 | 0.008 | 0.046 | 0.032 |
| 11/7 | 0.017 | 0.004 | 0.000 | 0.000 | 0.017 | 0.012 | 0.017 | 0.004 | 0.051 | 0.020 |
| 11/8 | 0.008 | 0.004 | 0.000 | 0.000 | 0.013 | 0.016 | 0.004 | 0.004 | 0.025 | 0.024 |
| 11/9 | 0.021 | 0.008 | 0.013 | 0.000 | 0.017 | 0.020 | 0.008 | 0.008 | 0.059 | 0.036 |
| 11/13 | 0.013 | 0.004 | 0.013 | 0.004 | 0.013 | 0.020 | 0.004 | 0.008 | 0.042 | 0.036 |
| 11/14 | 0.021 | 0.008 | 0.013 | 0.008 | 0.021 | 0.016 | 0.008 | 0.008 | 0.064 | 0.039 |
| 11/15 | 0.013 | 0.004 | 0.004 | 0.000 | 0.017 | 0.028 | 0.000 | 0.008 | 0.034 | 0.039 |
| 11/16 | 0.013 | 0.004 | 0.008 | 0.012 | 0.017 | 0.024 | 0.004 | 0.004 | 0.042 | 0.043 |
| 11/19 | 0.021 | 0.004 | 0.000 | 0.012 | 0.025 | 0.016 | 0.008 | 0.016 | 0.055 | 0.047 |
| 11/20 | 0.013 | 0.012 | 0.004 | 0.012 | 0.021 | 0.020 | 0.013 | 0.008 | 0.051 | 0.051 |
| 11/21 | 0.021 | 0.000 | 0.013 | 0.008 | 0.059 | 0.031 | 0.000 | 0.035 | 0.093 | 0.075 |
| 11/26 | 0.013 | 0.012 | 0.000 | 0.020 | 0.021 | 0.008 | 0.009 | 0.020 | 0.043 | 0.059 |
| 11/27 | 0.013 | 0.008 | 0.009 | 0.020 | 0.021 | 0.004 | 0.013 | 0.004 | 0.056 | 0.035 |
| 11/28 | 0.017 | 0.020 | 0.004 | 0.024 | 0.038 | 0.020 | 0.017 | 0.000 | 0.077 | 0.063 |
| 11/29 | 0.021 | 0.012 | 0.009 | 0.016 | 0.021 | 0.004 | 0.004 | 0.020 | 0.055 | 0.051 |
| 12/3 | 0.021 | 0.008 | 0.009 | 0.031 | 0.026 | 0.008 | 0.000 | 0.024 | 0.055 | 0.071 |
| 12/4 | 0.017 | 0.004 | 0.004 | 0.020 | 0.021 | 0.004 | 0.004 | 0.012 | 0.047 | 0.039 |
| 12/5 | 0.030 | 0.004 | 0.000 | 0.024 | 0.030 | 0.008 | 0.009 | 0.016 | 0.068 | 0.052 |
| 12/6 | 0.004 | 0.008 | 0.004 | 0.032 | 0.021 | 0.012 | 0.004 | 0.004 | 0.034 | 0.056 |
| 12/7 | 0.004 | 0.008 | 0.009 | 0.020 | 0.026 | 0.000 | 0.000 | 0.016 | 0.038 | 0.044 |
| 12/10 | 0.013 | 0.008 | 0.000 | 0.020 | 0.017 | 0.008 | 0.004 | 0.016 | 0.034 | 0.052 |
| 12/11 | 0.004 | 0.004 | 0.004 | 0.016 | 0.030 | 0.004 | 0.000 | 0.012 | 0.038 | 0.036 |
| 12/12 | 0.013 | 0.000 | 0.017 | 0.008 | 0.004 | 0.004 | 0.008 | 0.008 | 0.042 | 0.020 |
| 12/13 | 0.013 | 0.000 | 0.017 | 0.004 | 0.013 | 0.016 | 0.000 | 0.000 | 0.042 | 0.020 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 12/14 | 0.008 | 0.012 | 0.004 | 0.012 | 0.034 | 0.016 | 0.021 | 0.020 | 0.068 | 0.060 |
| **Mean** | **0.014** | **0.006** | **0.008** | **0.011** | **0.021** | **0.014** | **0.007** | **0.012** | **0.050** | **0.043** |
| **Lower CI** | **0.009** | **0.003** | **0.003** | **0.004** | **0.013** | **0.009** | **0.003** | **0.006** | **0.039** | **0.033** |
| **Upper CI** | **0.019** | **0.009** | **0.013** | **0.018** | **0.028** | **0.019** | **0.011** | **0.018** | **0.060** | **0.053** |

Mean post-intervention absentee rates shown in table 9 show considerable variation, however only the difference in absentees for respiratory illnesses between the control school (0.014) and the program school (0.006) achieves even marginal significance. In contrast to the respiratory absentees, the gastrointestinal absentees were higher for the program school than the control during the post-intervention period, although the difference was not significant. Overall, total absentee rates for the post intervention period were similar for the both the program and control school, (0.043 and 0.050 respectively).

Figures 5,6,7, 8 and 9 plot absentee rates for each type of absentee and total absentee for the program and control schools over time. The plotted data points presented considerable scattering and trend lines plotted from rolling 3 day averages have been included. Figure 5, showing respiratory absentees shows not only the variability of the data even after the smoothing effect of the rolling averages. Within this variability several distinct peaks suggests the presence of illness clusters described earlier. In addition, it is possible to detect the higher rates absentees in the control school. No clear trend of decreasing absenteeism in the program school is apparent in the post-intervention period.

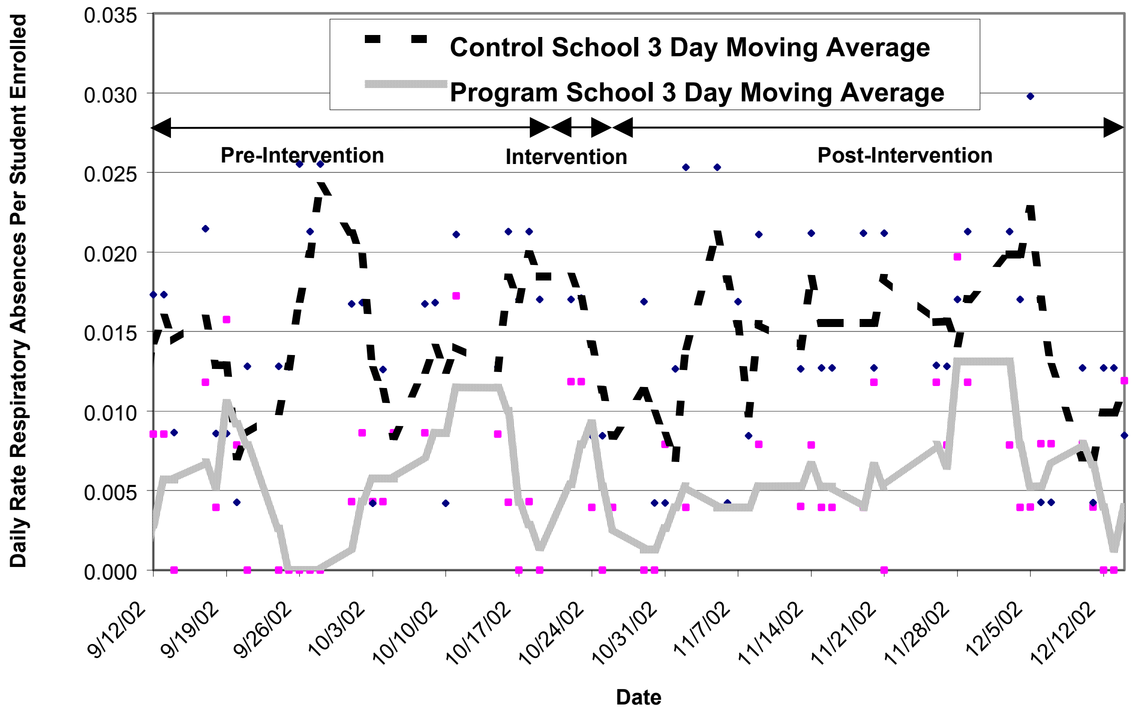



**Figure 5 Respiratory Absences for Program and Control Schools**

Certain patterns in rates of gastrointestinal illness absentees are shown in figure 6. Most noticeable is the illness cluster observed in the control school at the start of the pre-intervention period. Also noticeable is a rise in rates in the program school towards the end of the post-intervention period. This illness cluster appears different from the pre-intervention cluster identified in the control school with a lower maximum absentee rate of 0.032 for the program school compared to 0.052 for the control school. However, the programs school illness cluster was longer lasting with noticeably elevated rates over 10 school days compared to only 4 school days for the control school illness cluster. While it is possible that such peaks could reflect a common external exposure such as a private party, which would not have been influenced by the intervention, discussion with school personnel failed to identify a common exposure external to the school. As a result, the data could not be discounted from the overall analysis. Similarly to the absentee rates for respiratory illness, no noticeable trend of reduced absentee rates was observed at the program school following the intervention.

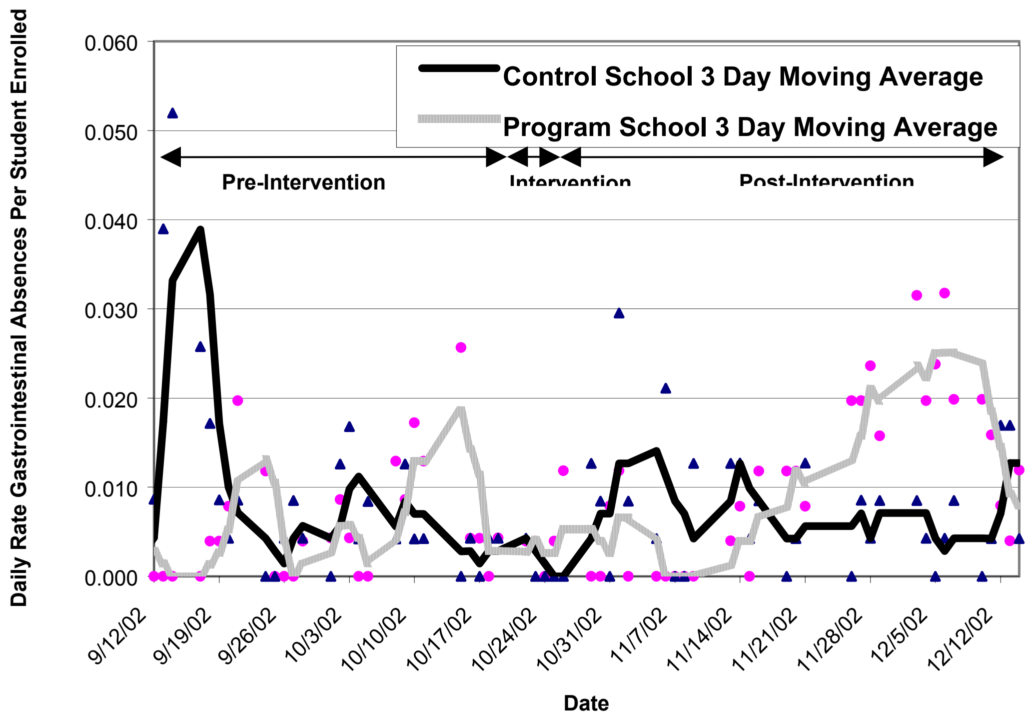



**Figure 6 Gastrointestinal Absences for Program and Control Schools**

Rates of absentees for other reasons shown in figure 7 again suggest considerable variability over time. Generally it appears that compared to the control school the program school had higher rates of absentees for other reasons in the pre-intervention period and lower rates in the post-intervention periods. Although this is supported in higher respective means shown in tables 7 and 9, as we saw these differences were not significant. To determine if there was a time trend that was not being reflected in the men data, Pearson Correlation coefficients were calculated to determine any correlation between time, reflected in number of days in the study, and daily absenteeism rates. The results of this analysis are displayed in table 10.

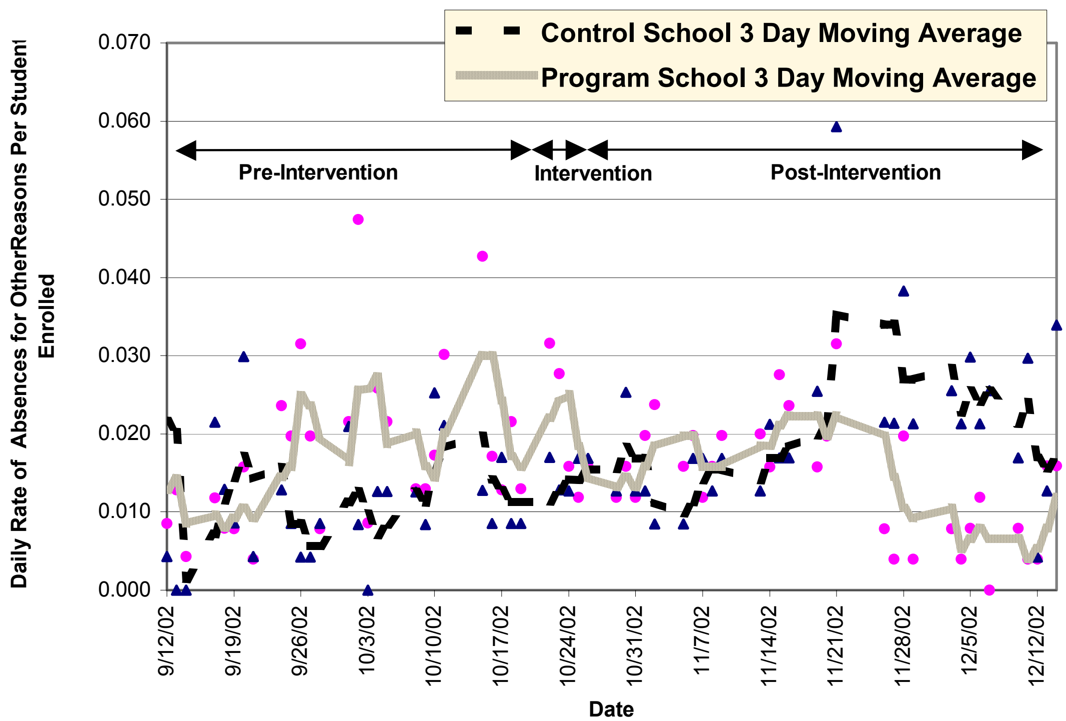



**Figure 7 Program and Control Schools Absences for Other Reasons**

**Table 11 Pearson Correlation Coefficient for Absentee Rates and Time**

| | Respiratory Abs. | | Gastro. Abs. | | Other Absences. | | Unknown Abs | | Total Absences | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cont. | Prog. | Cont. | Prog. | Cont. | Prog. | Cont. | Prog. | Cont. | Prog. |
| **Pearson Correlation** | 0.023 | 0.190 | -0.172 | 0.503 | 0.391 | -0.137 | 0.038 | -0.055 | 0.216 | 0.231 |
| **Sig. (2-tailed)** | 0.851 | 0.123 | 0.164 | 0.000 | 0.001 | 0.267 | 0.760 | 0.659 | 0.080 | 0.060 |

Significant positive correlations were identified for absentees for other reasons at the control school and for gastrointestinal absentees at the program school. The cluster of illnesses described earlier may explain the latter correlation. Interpretation of the former correlation is difficult due to the breadth of this category however it may reflect changes in the categorizing of data by school staff. Additional study is warranted to determine if this is the case.

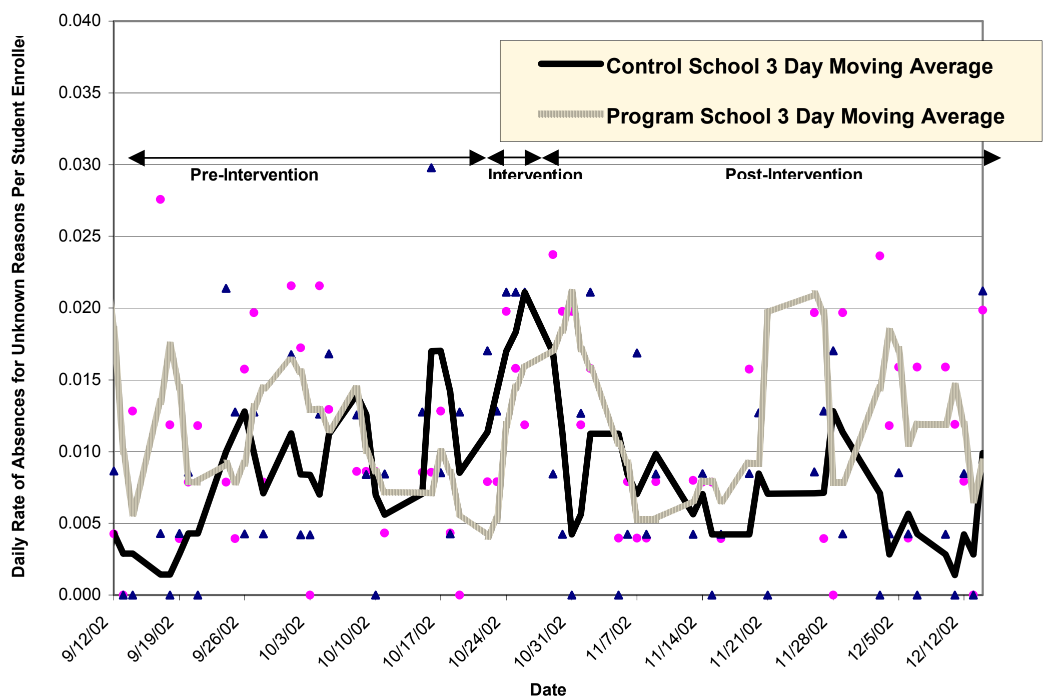
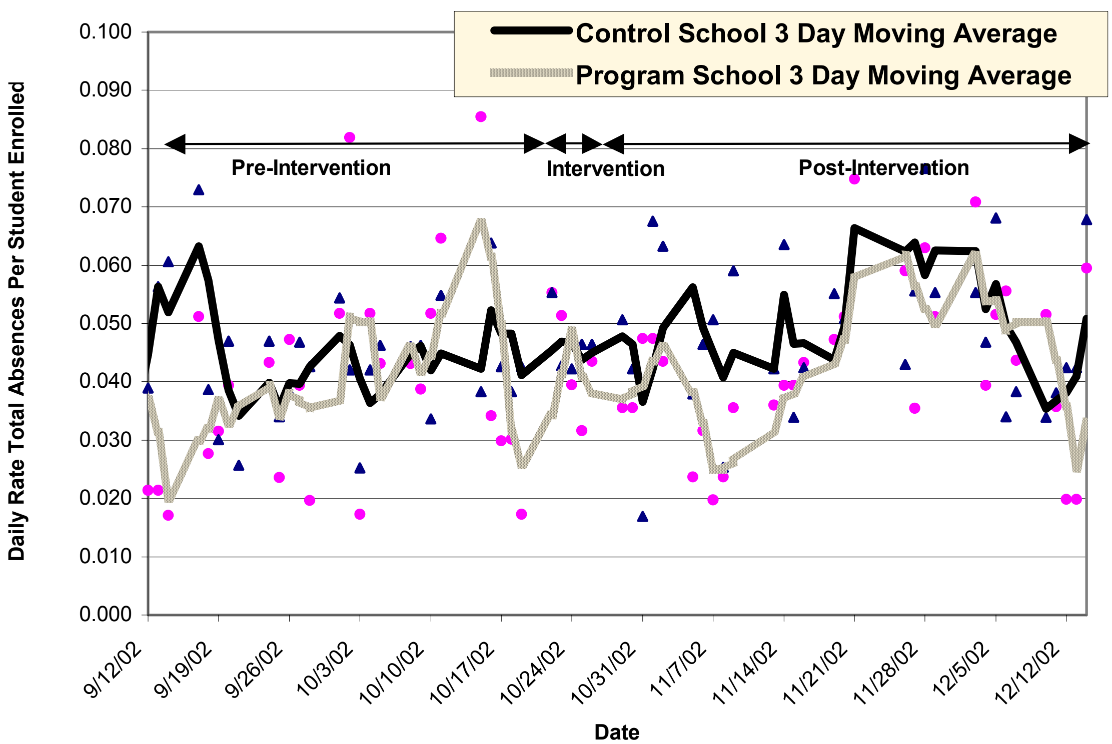



**Figure 8 Program and Control Schools Absences for Unknown Reasons**

Absentees for unknown reasons shown in figure 8 again suggest significant variance in rates over time. The similarity in rates shown in tables 7 and 9 is supported by the similar patterns in the trend lines in figure 8. This is important as it suggests that there was little difference in the extent of effort to which staff at the two schools would go in trying to determine the cause of the absence before coding it as unknown. In addition, the relative stability of these rates over time indicated by the non-significant correlations with time shown in table 10, suggest that the procedures employed by attendance staff to determine absences did not vary over the length of the study period.




## Figure 9 Total Absentee Rates at Program and Control Schools

Total absentee rates shown figure 9 suggest similar overall rates of absentees for the program and control schools, with obvious reduction in absentee rates at the program school following the intervention. In addition, no clear trend over time is apparent for either school, supporting the weak correlation with time shown table 10. The similarity in rates is important as all things being equal it supports any difference in any of the contributing rates reflecting differences in coding rather than the effect of the program. If the program were effective both gastrointestinal or respiratory rates AND total rates would be expected to be effected.

Table 11 and figure 10 provide an overall summary of differences between mean pre and post-intervention absentee rates for both schools with positive differences indicating a rise in rates in the post-intervention period.

**Table 12 Difference in Mean Pre and Post Intervention Rates of Absenteeism Per Child Day for Program and Control Schools**

| | Respiratory Abs. | | Gastro. Abs. | | Other Absences. | | Unknown Abs | | Total Absences | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cont. | Prog. | Cont. | Prog. | Cont. | Prog. | Cont. | Prog. | Cont. | Prog. |
| **Pre** | 0.014 | 0.005 | 0.009 | 0.005 | 0.012 | 0.017 | 0.008 | 0.012 | 0.043 | 0.039 |
| **Post** | 0.014 | 0.006 | 0.008 | 0.011 | 0.021 | 0.014 | 0.007 | 0.012 | 0.050 | 0.043 |
| **Difference Post-Pre** | 0.000 | 0.001 | -0.001 | 0.006 | 0.008 | -0.003 | -0.001 | 0.001 | 0.006 | 0.004 |

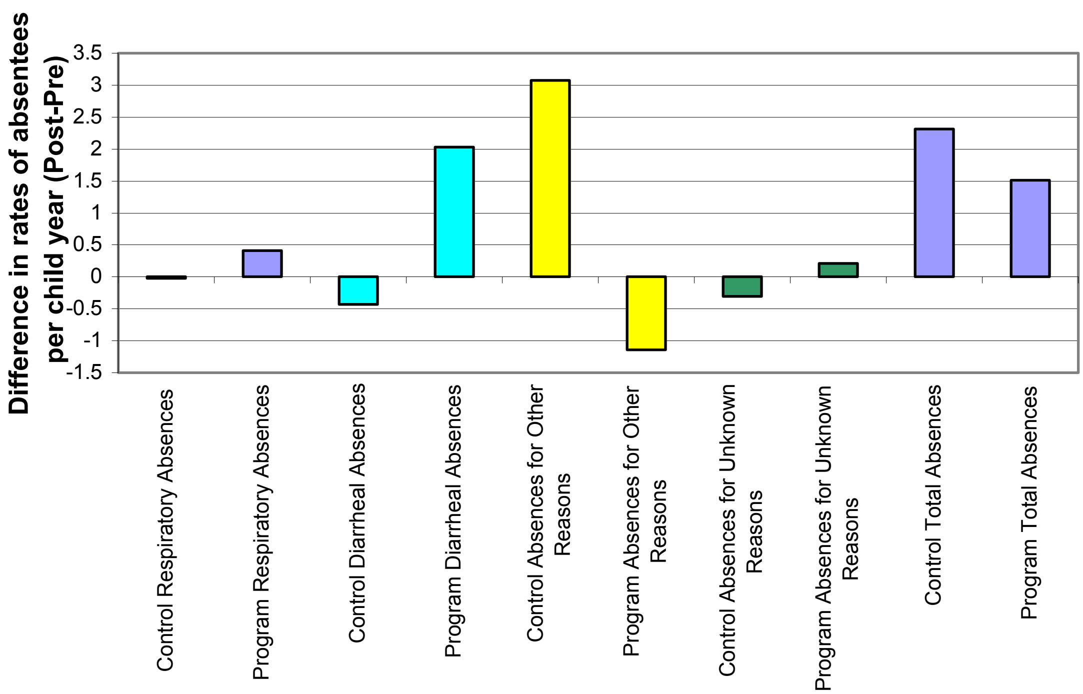



**Figure 10 Differences Between Post and Pre-Intervention Mean Rates of Absences Per Child Year for Handwashing Program Participant School and Control School**

Most noticeable from this figure is the increase in diarrheal illnesses in the program school compared to the control and the large increase in absences for other reasons at the control school compared to the program school. The effect of these differences largely cancels each other out with over differences in absentees comparable between the two groups.

To establish the overall effect of the handwashing program on absenteeism and make use of both pre and post AND program and control data in one test differences between pre and post programs measures were compared using the following statistic[h]:

p00=pre-intervention absenteeism rate at control school
p01=post-intervention absenteeism rate at control school
p10= pre-intervention absenteeism rate at intervention school
p11= post-intervention absenteeism rate at intervention school

d0=p01-p00=difference in absenteeism rate at control school
d1=p11-p10=difference in absenteeism rate at intervention school

n00= pre-intervention child days at risk in control school
n01= post-intervention child days at risk in control school
n10= pre-intervention child days at risk in intervention school
n11= post-intervention child days at risk in intervention school

var0=[(p00*(1-p00)/n00) + (p01*(1-p01)/n01)] = variance for d0
var1=[(p10*(1-p10)/n00) + (p11*(1-p11)/n11)]variance for d1

T= (d1-d0) +/- 1.96*sqrt(var0+var1)

The results of this test are shown in table 12 and test if there is a difference between the schools in the absentee rate change.  This method takes into account the different rates of absentees for each school during the pre-intervention period.

[h] This test was suggested by Laura L. Johnson, University of Washington Depoartemt of Biostatistics

## Table 13 Comparison of Differences in Pre and Post Rates of Absenteeism for Program and Control Schools

| | Respiratory Abs. | Gastro. Abs. | Other Absences. | Unknown Abs | Total Absences |
|---|---|---|---|---|---|
| **Difference Program-Control** | 0.001 | 0.007 | -0.011 | 0.001 | -0.002 |
| **CI lower** | -0.003 | 0.003 | -0.017 | -0.003 | -0.011 |
| **CI Upper** | 0.006 | 0.011 | -0.006 | 0.006 | 0.007 |

If the difference in rate change indicated in table 12 is positive it indicates that there was a larger increase in rate change for a particular type of absentee for the program school, a negative difference implies a larger increase for the control school. The significance of the difference is determined if the 95% confidence interval does not include 0. From these data we see that the increase in gastrointestinal absentees between the pre-intervention and the post intervention was significantly larger for the program school than for the control school, (difference 0.007 CI 0.003-0.011). In contrast, the increase in absentees for other reasons between the pre-intervention and the post-intervention was significantly larger for the control school than for the program school, (difference –0.011 CI –0.017 to –0.006). None of the other differences were statistically significant.

Table 13 shows the results of comparing cumulative incidence rates of types of absentees. The differences are tested with a chi-square statistic to provide the shown p-values. a This is a more traditional method of testing differences that does not take into account either the variance in rates within each group or the difference in rates prior to the intervention. The results are included here to allow comparison to existing literature on the subject.

## Table 14 Incidence Rates and Ratios for Absentees at Program and Control Schools

| | | | Resp Abs. | Gastr. Abs. | Other Abs. | Unkn. Abs | Total |
|---|---|---|---|---|---|---|---|
| Pre | Control | Total | 105 | 65 | 89 | 56 | 315 |
| | | Child Days at Risk | 7276 | 7276 | 7276 | 7276 | 7267 |
| | | Episodes per child day | 0.014 | 0.009 | 0.012 | 0.008 | 0.043 |
| | | days not ill | 7171 | 7211 | 7187 | 7220 | 6952 |
| | | Post/Pre Incidence Ratio | 0.995 | 0.871 | 1.702 | 0.887 | 1.152 |
| | | p value | 0.969 | 0.505 | <.001 | 0.607 | 0.078 |
| | Program | Total | 35 | 40 | 127 | 86 | 288 |
| | | Child Days at Risk | 7445 | 7445 | 7445 | 7445 | 7445 |
| | | Episodes per child day | 0.005 | 0.005 | 0.017 | 0.012 | 0.039 |
| | | days not ill | 7410 | 7405 | 7318 | 7359 | 7157 |
| | | Prog/ Control Inc.Ratio | 0.326 | 0.601 | 1.395 | 1.501 | 0.892 |
| | | p value | <.001 | 0.01 | 0.015 | 0.021 | 0.166 |
| Post | Control | Total | 105 | 57 | 151 | 50 | 363 |
| | | Child Days | 7315 | 7315 | 7315 | 7315 | 7315 |
| | | Episodes per child year | 0.014 | 0.008 | 0.021 | 0.007 | 0.050 |
| | | Days not ill | 7210 | 7258 | 7164 | 7265 | 6952 |
| | Program | Total | 46 | 86 | 110 | 95 | 337 |
| | | Child Days | 7844 | 7844 | 7844 | 7844 | 7844 |
| | | Episodes per child year | 0.006 | 0.011 | 0.014 | 0.012 | 0.043 |
| | | Days not ill | 7798 | 7758 | 7734 | 7749 | 7507 |
| | | Post/Pre Incidence Ratio | 1.249 | 2.052 | 0.820 | 1.049 | 1.116 |
| | | p value | 0.379 | <.001 | 0.146 | 0.749 | 0.195 |
| | | Prog/ Control Inc.Ratio | 0.409 | 1.407 | 0.679 | 1.772 | 0.866 |
| | | p value | <.001 | 0.053 | 0.002 | 0.001 | 0.056 |

Table 13 shows the significant difference increase in rates of absentees for other reasons between the pre and post intervention periods, (incidence ratio= 1.702 p=<0.001) and a significant increase in gastrointestinal illnesses in the program school during the study (incidence ratio = 2.052 p=<0.001). The data also show the significant differences in all rates except total absentees between the program and control schools in the pre-intervention period (incidence ratios 0.326 p=0.001, 0.601 P=0.01, 1.395 P=0.015, 1.501 P=0.021). The data also show significant differences in incidence ratios between the program and control schools in post intervention absentee rates for respiratory absentees (incidence ratio= 0.409 p=<0.001), absentees for other reasons (incidence ratio = 0.679 p=0.002) and absentees for unknown reasons (incidence ratio = 1.772 p=0.001). However, with the exception of absentees for other reasons, these differences should not be considered as related to the intervention, but as continuations of differences that were significant prior to the intervention.

## Limitations

Several important limitations of the data are important in the analysis of the results of this study. Firstly, although identical instructions were given to the attendance secretaries at both schools, some differences in categorizing types of absentees is possible. Without independent confirmation of these results by medical staff, this is an important concern and may in part explain the differences in rates of absentees prior to the intervention. Secondly, the absentee data do not differentiate between absentee days and periods of absence per student. As a result, one student who had an extended period of absence would be equally weighted as a number of students who were ill for one day. In terms of preventing absenteeism, this could dilute the positive effects of the intervention. Thirdly, soap usage data is prone to error both from tampering with dispensers, leakage, unequal quantities dispensed and unauthorized refilling of the soap containers by school staff. In addition, while soap is a reasonable proxy for the frequency and quality of handwashing undertaken, it is far from perfect. For example, some students may use excessive amounts of soap while some may hardly use any. Also, soap usage does not reflect how long or vigorously hands were lathered, nor does it indicate that the rinse water was of adequate temperature. Likewise, soap usage at boys' and girls' restroom handwash sinks may include usage by students in grades 4 and 5, not included in the study- while this error was common to both schools it has at best a moderating influence upon any observed effects of the program.

## Discussion

The complex picture suggested by these data make drawing clear conclusions difficult. The large increase in soap usage during the intervention is understandable given that the program required that all students washed their hands under supervision at both restroom and classroom handwash sinks during the intervention. Generally it appears that the intervention was effective in increasing soap usage compared to the control school, although the small sample size, inclusion of soap usage by students not in the study population and considerable variability in usage rates meant that significant differences were unlikely. The amount of this relative increase is less than might be expected from an intervention that asked that teachers supervise handwashing.

The decrease in soap usage for both the program and control schools is difficult to understand and may reflect changes in teacher instruction to students over time. For example, teachers over the course of the quarter may become less strict about requiring students to wash their hands before lunch. Clearly this finding deserves further study to find out if this is phenomenon extends beyond the study population. The findings of such research may point to targets for future interventions aimed at improving handwashing practices.

It is interesting to note that the decline in soap usage at the boys' restroom handwash sinks was similar for both program and control schools. By contrast, after the program far more soap was used at the program school girls' restroom handwash sink than at the control school. This could point to girls being more receptive to the handwashing promotion program. Additional study might examine this difference and could be used to more finely target handwashing messages to populations within the school.

It is easy to criticize the use of soap usage as a proxy for handwashing, however some measure of the quality and quantity of handwashing occurring as a result of the intervention is a vital intermediate outcome. This is especially true when the ultimate outcome of absenteeism is susceptible to history effects such as seasonality of diseases or the entry of ill students into the student population. The alternatives to soap usage as a proxy for handwashing quality are also not without problems. For example observed handwashing has been used[25] to determine if hands are being washed after visiting the restroom, however it is likely that the presence of an observer will influence the behavior of study subjects and clandestine surveillance may present ethical challenges.

The design of this evaluation study is unusual as it includes both pre and post comparison in addition to program and control comparisons. This allows for an interesting comparison of methods that shows significant weaknesses with both. For example used alone, the pre and post method applied to the program school would not have been able to explain the decreasing consumption of soap over the quarter as something separate from the intervention. Likewise, relying only on post intervention measures compared to a control facility it would have been impossible to detect the significantly different rates in both absenteeism and soap usage that were features of the schools before the intervention began.  Only by using a method that compares the relative differences in the pre-post change for both the program and the control can these problems be avoided

It is almost certainly unreasonable to attribute the significant increase in gastrointestinal illness absentees in the program school following the intervention to the handwashing program.  This speaks to the variability of absentee rates in an elementary school population where small outbreaks occur frequently.  While it may be argued that good student handwashing practices should have stopped an outbreak, it can also be argued that good handwashing practices may have limited the spread of this otherwise much more serious outbreak. While this argument is largely academic, it is clear that significant outbreaks do not occur with sufficient frequency to preclude the inclusion of one in the program school and not in the control to be merely a matter of chance Also, worthy of note, is the significant increase in absentees for other reasons in the control school following the intervention without a corresponding overall increase in absentees.  This may point to changes in categorizing practices of attendance staff at the control school.  This bias may have weakened the relative effect of the handwashing program at the program school to reduce rates of respiratory illnesses.  These factors aside, significant decreases in absenteeism for both infectious illnesses and overall absentees were not seen, suggesting that either handwashing is not effective in reducing such absentees or that the program was not effective in sufficiently improving handwashing practices.

Several factors support the conclusion that the handwashing program as provided was not effective in sufficiently improving handwashing practices.  In contrast with other studies, [26,28] this study merely asked teachers to supervise handwashing at key times of the day and did not require supervised handwashing. No observations were made to determine the extent to which this occurred. Handwashing promotion programs which rely upon enforced school policies and procedures to require handwashing at key times of the day may be more effective. In addition, the schools for this study were selected by the researcher to meet the requirements set down in the methods. By contrast, previously this intervention had been undertaken with schools where the staff had sought out and invited the program in. As a result, the staff at the program school may have been less motivated to ensure the success of the program than is usually the case for a school receiving the program.

Another factor that may have limited the success of the program in comparison to previous studies[26,28] is that the intervention lasted only a week. Although the program emphasized repetition of key messages it may be less effective than a less intensive program of activities and reminder materials that may run over the entire quarter or year.

Finally, the selection of the schools may have resulted in schools that would gain little from the program. Schools vary greatly in the quality and quantity of handwashing occurring. This may be a result of policy, from handwashing education already being included in the curriculum or from facilities where good handwashing facilities allow convenient and frequent handwashing. In this respect, the control school classes were anecdotally reported to wash their hands as a class at least once a day. With regard to facilities, the program school was less than ten years old with good handwashing facilities in the restrooms and the control school featured several large communal fountain type handwashing basins which allow a large number of students to wash their hands at once. As a result, both schools were likely to have good rates of handwashing, weakening the effect of the intervention on both increasing soap usage and reducing absentees.

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